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MODELING THE MISSILE-LAUNCH TUBE PROBLEM IN DYSCO

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INTRODUCTION

DYSCO is a versatile, general purpose dynamic analysis program which assembles equations and solves dynamics problems. The "executive" manages a library of technology modules which contain routines that compute the matrix coefficients of the second order ordinary differential equations of the components. The executive performs the coupling of the equations of the components and manages the solution of the coupled equations.

Any new component representation may be added to the library if, given the state vector, one can write a FORTRAN program to compute M, C, K, F. The problem described in this report demonstrates the generality of this statement.

- **DYSCO - MODELS AND SOLVES DYNAMIC SYSTEMS**
- **EXECUTIVE MANAGES A LIBRARY OF TECHNOLOGY MODULES**
- **TECHNOLOGY MODULES DEFINE SECOND ORDER ODE (M, C, K, F)**
- **EXECUTIVE COUPLES COMPONENTS AND MANAGES SOLUTIONS**
- **NEW MODULES MAY BE ADDED TO LIBRARY IF:**

  <u>**GIVEN THE STATE OF THE COMPONENT, A FORTRAN PROGRAM CAN COMPUTE M, C, K, F**</u>

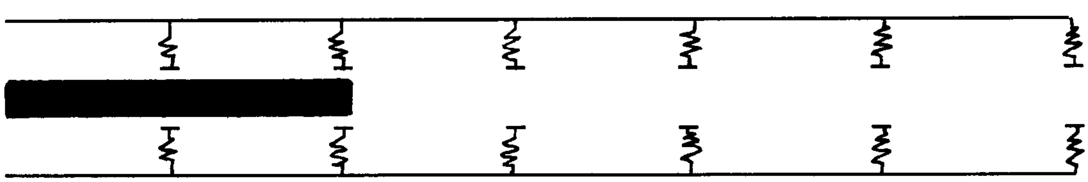
Figure 1

MISSILE - LAUNCH TUBE PROBLEM

Consider an elastic body (missile) moving through an elastic tube. The inside of the tube is populated with snubbers having spring and damper characteristics with gaps between the missile and the snubbers.

The complete problem also must include aerodynamic effects, control devices and algorithms, and propulsive force history. All of these are readily treated in DYSCO.

The emphasis of this presentation will be the treatment of time varying constraints.



CHARACTERISTICS

MISSILE AND TUBE ARE ELASTIC BODIES
GAPS EXIST BETWEEN MISSILE AND SNUBBERS
AERODYNAMIC EFFECTS, CONTROLS, PROPULSIVE FORCE MUST BE CONSIDERED

BASIC PROBLEM IS TIME VARYING CONSTRAINTS

Figure 2

NEW DYSCO COMPONENT, CMS1

The component illustrated in Figure 3a was added to the technology library. The "MS" stands for "moving structure." Note that there are no dynamic characteristics associated with the degrees of freedom in this component. The names of the DOF Z_1, ... Z_N are arbitrary and supplied by the user. When these correspond to those of another component, DYSCO automatically performs the dynamic coupling. The same is true of the DOF Z_L and Z_U.

Figure 3b illustrates a particular state of the system and illustrates how the force vector is coupled (M, C, K are treated as null). In this illustration, forces act only on DOF Z4, Z5, and ZU. All other forces are zero.

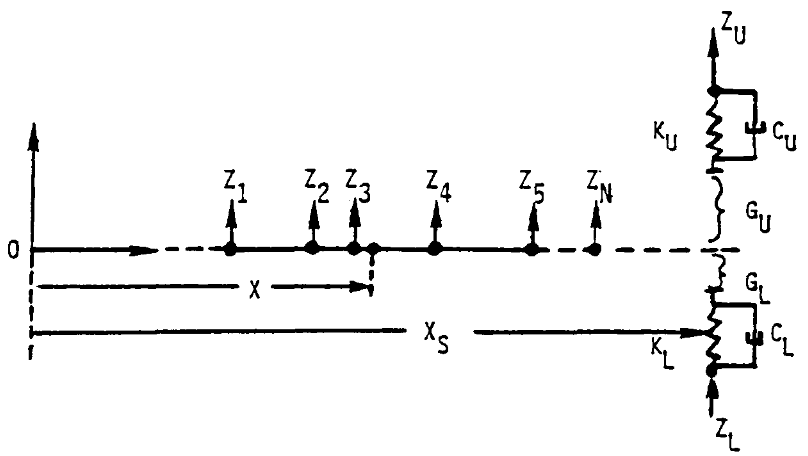


Figure 3a

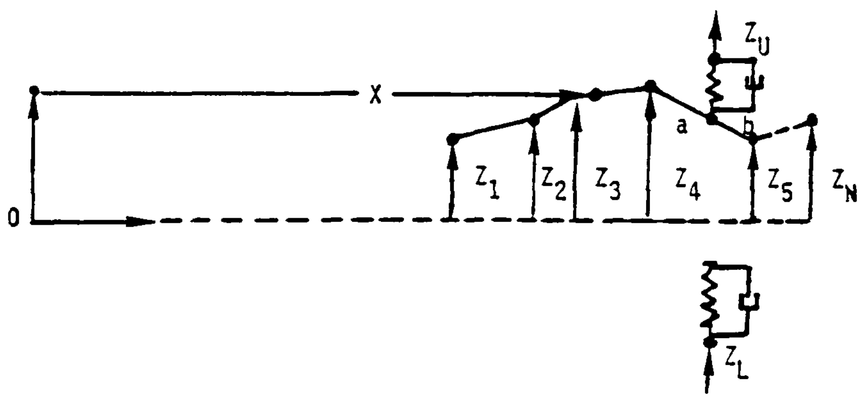
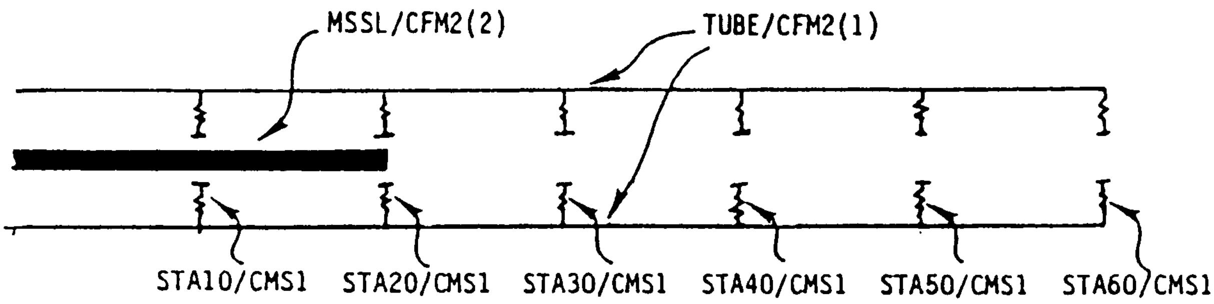


Figure 3b

MISSILE-LAUNCH TUBE MODEL

The figure illustrates the DYSCO model used to represent this problem. The missile and the tube are represented by modal representations (CFM2), six snubbers as previously described (CMS1) are used, each identified by the tube station at which it is located.



****************************** MODEL MT ****************************

BASIC MISSILE IN TUBE

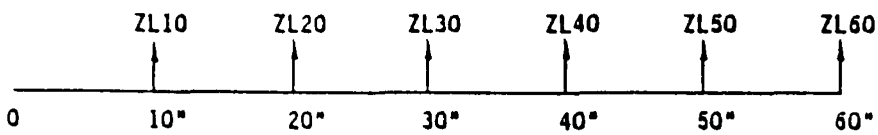
INDEX	COMP	NO.	DATA SET	FORCE	DATA SET
1	CFM2	1	TUBE	NONE	
2	CFM2	2	MSSL	NONE	
3	CMS1		STA10	NONE	
4	CMS1		STA20	NONE	
5	CMS1		STA30	NONE	
6	CMS1		STA40	NONE	
7	CMS1		STA50	NONE	
8	CMS1		STA60	NONE	

****

Figure 4

TUBE DATA SET

This set of data defines the tube used in the sample analysis. Note the DOF names shown are also used on the snubber springs and dampers and are thus automatically attached to the tube at the proper station.



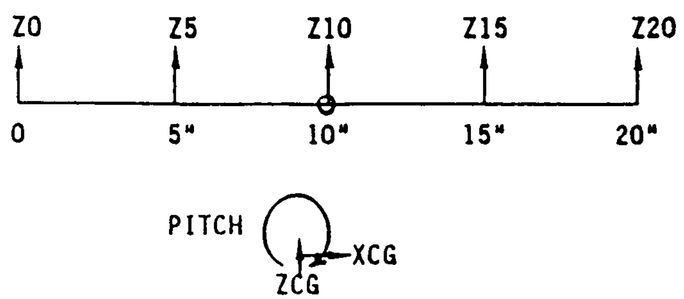
1 elastic mode, 5 hz

```
****************************         TUBE / CFM2      ****************************
MISSILE LAUNCHER - NO X DOF. COMP 1.
**********************************************************************************
INPUT FOR STRUCTURAL     COMPONENT CFM2. MODAL FUSELAGE
  1 RBM         - RIGID BODY MODES      =       NO
  2 NMOD        - NO. OF ELASTIC MODES =         1
  3 NS          - NO. FUSELAGE STAS    =         6
  4 X           - (REAL) INPUT STATION VALUES
               -2.00000E+01  -1.00000E+01   0.00000E+00   1.00000E+01
                2.00000E+01   3.00000E+01
  5 VC1         - MODE1 VERTICAL COMP  =        YES
  6 Z1          - (REAL) MODE1 VERTICAL DISP
                2.00000E-01  -4.00000E-01  -6.00000E-01  -4.00000E-01
                2.00000E-01   1.00000E+00
  7 ZP1         - (REAL) MODE1 VERTICAL SLOPE
                0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
                0.00000E+00   0.00000E+00
  8 LC1         - MODE1 LATERAL COMP   =        NO
  9 TC1         - MODE1 TORSION COMP   =        NO
 10 NR          - NO. OF ROTORS        =         0
 11 NI          - NO. OTHER IMPLCT DOF =         6
 12 CIDFL       - (DOF) IMPLICIT DOF NAMES
             ZL10   0   ZL20   0   ZL30   0   ZL40   0   ZL50   0
             ZL60   0
 13 XSTA        - (REAL) STAS FOR IMPLCT DOF
               -2.00000E+01  -1.00000E+01   0.00000E+01   1.00000E+01
                2.00000E+01   3.00000E+01
 14 AF          - (REAL) FWD ANGLE FROM VERT
                0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
                0.00000E+00   0.00000E+00
 15 AL          - (REAL) LAT ANGLE FROM VERT
                0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
                0.00000E+00   0.00000E+00
 16 MMS         - MODAL MASS (SLUGS)   = 2.00000E+00
 17 MD          - MODAL DAMPING (PCI)  = 0.00000E+00
 18 FREQ        - MODAL FREQUENCY (HZ) = 5.00000E+00
```

Figure 5

MISSILE DATA SET

This set of data defines the missile used in the sample analysis. Note the DOF names which are used in the new component.

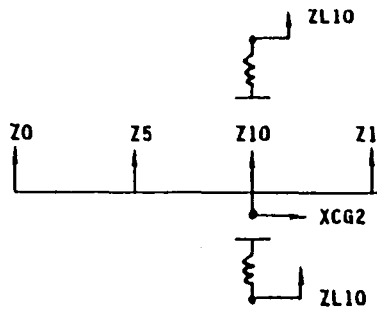



```
*****************************          MSSL /CFM2          ****************************
MISSILE - X DOF. COMP 2.
***************************************************************************************
INPUT FOR STRUCTURAL       COMPONENT CFM2. MODAL FUSELAGE

  1 RBM          - RIGID BODY MODES     =        YES
  2 IXCG         - LONGITUDINAL         =        YES
  3 IYCG         - LATERAL              =        NO
  4 IZCG         - VERTICAL             =        YES
  5 IROLL        - ROLL                 =        NO
  6 IPTCH        - PITCH                =        YES
  7 IYAW         - YAW                  =        NO

  8 CG           - CG STATION (IN)      =   0.00000E+00
  9 NMODE        - NO. OF ELASTIC MODES =             0
 10 NR           - NO. OF ROTORS        =             0
 11 NI           - NO. OTHER IMPLCT DOF =             5
 12 CIDFL        - (DOF) IMPLICIT DOF NAMES
            Z0   0   Z5   0   Z10   0   Z15   0   Z20   0
 13 XSTA         - (REAL) STAS FOR IMPLCT DOF
               -1.00000E+01  -5.00000E+00   0.00000E+00   5.00000E+00
                1.00000E+01
 14 AF          - (REAL) FWD ANGLE FROM VERT
                0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
                0.00000E+00   0.00000E+00
 15 AL          - (REAL) LAT ANGLE FROM VERT
                0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
                0.00000E+00   0.00000E+00
 16 MASSL        - FUSELAGE MASS (LB)    = 5.00000E+00
 17 IMYF         - PITCH MOI ABOUT CG    = 4.00000E-02
```

Figure 6

STA 10 SNUBBER DATA SET

Note the relationship between the DOF and those of the missile and the tube on previous figures.

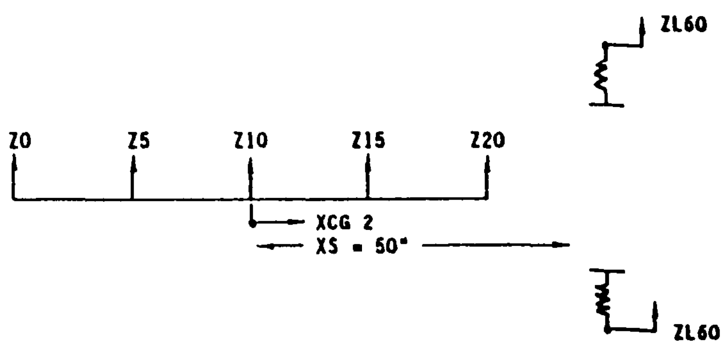



```
******************************       STA10/CMS1       ****************************
TUBE SNUBBER, STA 10
***********************************************************************************
INPUT FOR STRUCTURAL     COMPONENT CFM2. MODAL FUSELAGE
  1 IU          - UPPER BASE DOF        =       YES
  2 CDFLU       - UPPER BASE DOF NAME   =    ZL10   0
  3 KU          - UPPER SPRING COEFF    = 2.00000E+02
  4 CU          - UPPER DAMPER COEFF    = 0.00000E+00
  5 GU          - UPPER GAP             = 5.00000E-01
  6 IL          - LOWER BASE DOF        =       YES
  7 CDFLL       - LOWER BASE DOF NAME   =    ZL10   0
  8 KL          - LOWER SPRING COEFF    =  2.00000E+02
  9 CL          - LOWER DAMPER COEFF    =  0.00000E+00
 10 GL          - LOWER GAP             =  5.00000E-01
 11 CDFLX       - HORIZONTAL DOF NAME   =     XCG 2000
 12 XS          - BASE DISTANCE         =  0.00000E+00
 13 NCDFZ       - NO. OF VERTICAL DOF   =             5
 14 CDFLZ       - (DOF) VERTICAL DOF NAMES
            Z0    0   Z5    0   Z10   0   Z15   0   Z20   0
 15 XZ          - (REAL) VERT DOF STATIONS
             -1.00000E+01  -5.00000E+00   0.00000E+00   5.00000E+00
              1.00000E+01
```

Figure 7

STA 60 SNUBBER DATA SET

Note DOF names on this data set and how they relate to missile and tube data.




```
*****************************          STA60/CMS1          ****************************
TUBE SNUBBER, STA 60
*****************************************************************************************
INPUT FOR COMPONENT CMS1. MOVING CONSTRAINTS
  1 IU        - UPPER BASE DOF        =      YES
  2 CDFLU     - UPPER BASE DOF NAME   =    ZL60    0
  3 KU        - UPPER SPRING COEFF    = 2.00000E+02
  4 CU        - UPPER DAMPER COEFF    = 0.00000E+00
  5 GU        - UPPER GAP             = 5.00000E-01
  6 IL        - LOWER BASE DOF        =      YES
  7 CDFLL     - LOWER BASE DOF NAME   =    ZL60    0
  8 KL        - LOWER SPRING COEFF    =  2.00000E+02
  9 CL        - LOWER DAMPER COEFF    =  0.00000E+00
 10 GL        - LOWER GAP             =  5.00000E-01
 11 CDFLX     - HORIZONTAL DOF NAME   =    XCG 2000
 12 XS        - BASE DISTANCE         =  5.00000E+01
 13 NCDFZ     - NO. OF VERTICAL DOF   =           5
 14 CDFLZ     - (DOF) VERTICAL DOF NAMES
          Z0    0  Z5   0   Z10   0   Z15   0   Z20   0
 15 XZ        - (REAL) VERT DOF STATIONS
            -1.00000E+01  -5.00000E+00   0.00000E+00   5.00000E+00
             1.00000E+01
```

Figure 8

TIME HISTORY

This figure illustrates a sample time history of the missile with and without damping in the snubbers.

The procedure is shown to perform as planned.

Future enhancements could include more general shape functions, nonlinear springs, friction forces.

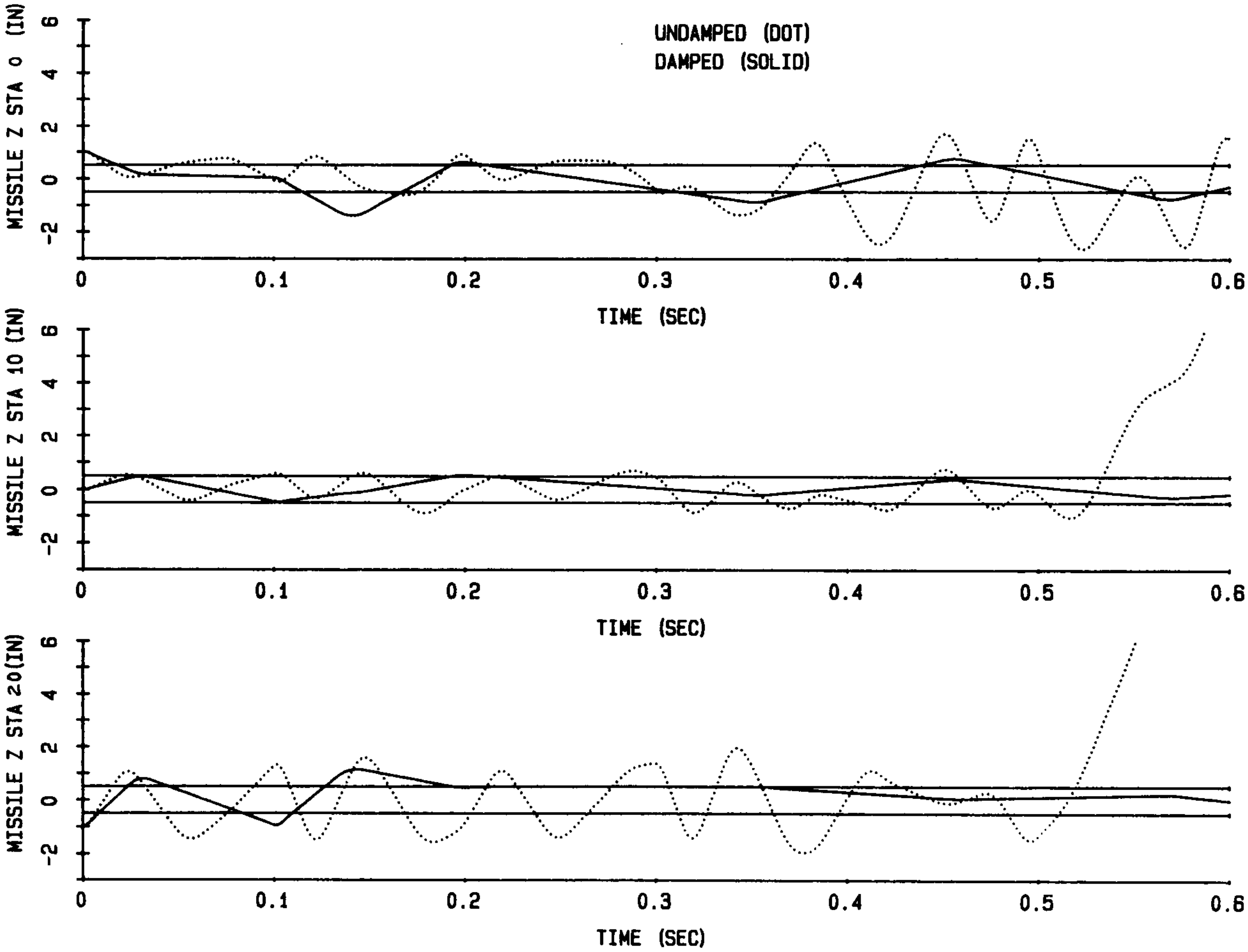


Figure 9